J. Helminthol. Soc. Wash.
61(1), 1994, pp. 17–21

Eimerian Species (Apicomplexa: Eimeriina) in Gunnison's Prairie Dogs (*Cynomys gunnisoni zuniensis*) and Rock Squirrels (*Spermophilus variegatus grammurus*) from Southeastern Utah

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ABSTRACT: *Eimeria callospermophili-morainensis* (prevalence = 78.9%), *E. beecheyi* (62.6%), *E. spermophili* (9.8%), *E. bilamellata* (8.1%), *E. larimerensis* (3.3%), *E. cynomysis* (1.6%), and 1 unidentified eimerian species were recovered from 123 fecal samples of Gunnison's prairie dogs (*Cynomys gunnisoni zuniensis*) collected in southeastern Utah. *Eimeria spermophili* has not been reported previously in any prairie dog species, and Gunnison's prairie dog is a new host record for 7 of the preceding species. Eighty-five percent of the samples contained at least 1 eimerian species, with multispecific infections of 2–4 species in 65% of the 123 samples. Species richness was 2.0 species/infected host. *Eimeria beecheyi* (100%), *E. morainensis* (85.7%), *E. callospermophili* (57.1%), and *E. bilamellata* (28.6%) also were recovered from 7 rock squirrels (*Spermophilus variegatus grammurus*). Individuals harbored from 2–5 eimerian species (species richness = 3.5). *Eimeria beecheyi* and *E. morainensis* have not been reported previously infecting rock squirrels. The unidentified eimerian species was recovered from 6 of the 123 prairie dog samples (4.9%) and 5 (71.4%) rock squirrels live-trapped in southeastern Utah. The eimerian complex described for these 2 sympatric host species is similar to those described in Wyoming ground squirrels and several other sciurid species. We propose that the ability of the spermophiline species of *Eimeria* to infect related host species contributes to the stability and persistence of this eimerian guild.

KEY WORDS: Gunnison's prairie dog, *Cynomys, Eimeria,* host specificity, prevalence, rock squirrels, *Spermophilus.*

Three species of *Eimeria* (*E. cynomysis* Andrews, 1928, *E. ludoviciani* Vetterling, 1964, and *E. larimerensis* Vetterling, 1964) have been reported infecting black-tailed prairie dogs (*Cynomys ludovicianus* Ord, 1815) (Andrews, 1928; Vetterling, 1964), and 7 species (*E. cynomysis, E. ludoviciani, E. larimerensis, E. bilamellata* Henry, 1932, *E. beecheyi* Henry, 1932, *E. callospermophili* Henry, 1932, and *E. morainensis* Torbett, Marquardt, and Carey, 1982) have been reported in white-tailed prairie dogs (*Cynomys leucurus* Merriam, 1890) (Todd and Hammond, 1968a, b; Seville and Williams, 1989; Shults et al., 1990). However, no species of *Eimeria* has been reported from Gunnison's prairie dogs (*Cynomys gunnisoni zuniensis* Baird, 1858).

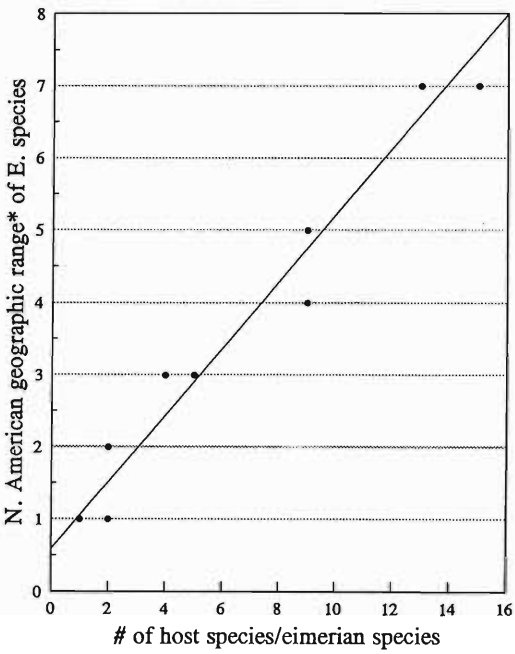
Two eimerian species (*E. bilamellata* and *E. larimerensis*) have been reported in wild rock squirrels (*Spermophilus variegatus grammurus* Erxleben, 1777) (Todd and Hammond, 1968b; Todd et al., 1968). Todd and Hammond (1968a) infected rock squirrels with *E. callospermophili* experimentally, but this species has not been recovered from naturally infected rock squirrels.

Here we report the occurrence of *Eimeria* recovered from 2 sympatric sciurid species from southeastern Utah, Gunnison's prairie dogs and rock squirrels, and compare the observed eimerian complex with those described in other sciurid rodents.

Methods

Fecal samples were collected from a population of Gunnison's prairie dogs 7 km east of Monticello, Utah (38°15′N, 109°51′W), over a 4-day period in May 1991. The colony was located in a rye (*Secale cereale*) field. Fresh fecal pellets were collected from the entrances of individual prairie dog burrows between sunrise and 0800 hours each morning. Only pellets in or at the entrance of the burrows were collected to avoid duplicate samples from the same individual. Fecal samples also were collected from 7 adult rock squirrels that were live-trapped within a 12 km radius of Monticello, Utah.

Feces were soaked in 2% aqueous potassium dichromate at room temperature (26–28°C) for several weeks to allow oocyst sporulation to occur. Oocysts were isolated by floatation and centrifugation in Benbrook's sugar solution, and species were identified based on oocyst size, shape, and internal structure. Because size ranges for *E. callospermophili* and *E. morainensis* overlap, differentiation of these 2 species depends on the internal structure of the sporulated oocyst. All 7 rock squirrel samples achieved sufficient sporulation of oocysts to differentiate between these 2 species. These eimerian species were also identified in the prairie dog samples; however, incomplete sporulation in some samples made prevalence impossible to determine. Therefore, although both species were positively identified, we combined the 2 (*E. callospermophili-morainensis*) for data on prevalence in the prairie dog.



n = 18

*Number of states (including Canada and Mexico)

Figure 1. The correlation between the size of the geographic range and the number of host species reported for 18 eimerian species of ground-dwelling sciurids in North America.

Results

Eighty-five percent of 123 prairie dog fecal samples were positive for *Eimeria.* Sixty-five percent of the samples had more than 1 eimerian species: 48.8% had 2 species, 13.8% had 3 species, and 2.4% had 4 species. The *E. callospermophili-morainensis* complex was the most prevalent (78.9%), followed by *E. beecheyi* (62.6%), *E. spermophili* Hilton and Mahrt, 1971 (9.8%), *E. bilamellata* (8.1%), *E. larimerensis* (3.3%), and *E. cynomysis* (1.6%). An unidentified eimerian species was found in 6 (4.9%) of the prairie dog samples.

All 7 rock squirrels had multiple eimerian infections: 2 squirrels harbored 2 species, 1 had 3 species, 3 were infected with 4 species, and 1 animal harbored 5 species. *Eimeria beecheyi* (100%) was the most prevalent, followed by *E. morainensis* (86%), *E. callospermophili* (57%), and *E. bilamellata* (29%). Oocysts of an unidentified species were also recovered from 5 (71%) of the rock squirrels. Although no cross-transmission studies or species-differentiating tests were performed, it appears that these oocysts are of the same species as the unidentified species recovered from the Gunnison's prairie dogs.

Oocysts of this species were ovoid to ellipsoidal, with a length–width ratio of approximately 1.2. Fifty-eight sporulated oocysts averaged 21.2 (19.6–23.8) × 26.0 (24.0–29.0) μm, and 53 unsporulated oocysts measured 21.3 (20.0–23.8) × 26.0 (24.0–28.5) μm. The oocyst wall appeared to be smooth, 1-layered, and approximately 0.8–1.0 μm thick. Oocysts lacked distinct micropyles and no polar granules were observed; however, sporulation appeared to be incomplete and internal structures were difficult to define. Of the eimerian species previously described in sciurid rodents, only *E. spermophili* is similar to this species in size and shape, but oocysts of the unidentified species display no thinning of the anterior oocyst wall characteristic of *E. spermophili.* Therefore, it appears that this species has not been described previously.

Discussion

Vetterling (1964) found 3 species of *Eimeria* in 86 black-tailed prairie dogs in northern Colorado, but data are insufficient to calculate species richness (the mean number of species/infected host). Seville and Williams (1989) reported 3 eimerian species in 17 white-tailed prairie dogs from Park County, Wyoming (species richness = 1.5), and Shults et al. (1990) found 3 species in 17 white-tailed prairie dogs (species richness unknown) and 6 species from 1,007 Wyoming ground squirrels from southeastern Wyoming (species richness = 1.9). Seville et al. (1992) reported 4 species of *Eimeria* in thirteen-lined ground squirrels (*Spermophilus tridecemlineatus* Mitchill, 1821) from 2 populations in Wyoming (species richness = 1.2 and 1.8). In this study, 8 eimerian species were recovered from Gunnison's prairie dogs, and the species richness was 2.0, despite the combination of *E. callospermophili* and *E. morainensis* into a single species complex. Gunnison's prairie dog is a new host record for 7 of these eimerian species.

Although only 7 rock squirrels were sampled, 3 of the 5 eimerian species recovered have not been previously recorded for this host. Species richness was high (3.5), but the sample size was small.

Gunnison's prairie dogs and rock squirrels are sympatric in southeastern Utah, and all 5 eimerian species found in rock squirrels were also

Table 1. Reported host species of 8 eimerian species of ground-dwelling sciurid.*

Host species	Eimerian species							
	E. beecheyi	*E. callo-spermophili*	*E. morai-nensis*	*E. lari-merensis*	*E. bila-mellata*	*E. sper-mophili*	*E. cyno-mysis*	UNID‡
Spermophilus elegans	17, 18	17, 18	17, 18	17, 18	17, 18	17, 18	—	—
S. armatus	—	10	—	9	8	—	—	—
S. beecheyi	1	10	—	9	8	—	—	—
S. variegatus	21	10, 21	21	9	8, 21	—	—	21
S. lateralis	—	1, 10	14	4, 9	1, 8	—	—	—
S. tridecemlineatus	19	10, 19	19	9, 19	19	—	—	—
S. columbianus	—	11	—	11	11	—	—	—
S. franklinii	—	11	—	—	2, 7, 11	11	—	—
S. richardsonii	20	10, 11, 20	20	11, 20	11, 20	11, 20	—	—
S. beldingii	—	15	—	—	—	—	—	—
S. spilosoma	—	7	—	12	—	—	—	—
S. townsendii	23	23	23	23	23	—	—	—
S. citellus	—	—	—	—	3, 5	—	—	—
S. maximus	—	7	—	—	—	—	—	—
S. relictus	13	—	—	—	—	—	—	—
Cynomys leucurus	17	10	17	9, 16	17	—	16	—
C. ludoviciani	—	—	—	6	—	—	6	—
C. gunnisoni	21	21	21	21	21	21	21	21
Marmota flaviventris	22	22	22	—	—	22	—	—
Total number of host species	10	16	9	13	13	5	3	2
Total number of host genera	3	3	3	2	2	3	1	2

* Numbers indicate references: 1 = Henry (1932), 2 = Hall and Knipling (1935), 3 = Pellérdy and Babos (1953), 4 = Levine et al. (1957), 5 = Ryšavý (1957), 6 = Vetterling (1964), 7 = Levine and Ivens (1965), 8 = Todd and Hammond (1968b), 9 = Todd et al. (1968), 10 = Todd and Hammond (1968a), 11 = Hilton and Mahrt (1971), 12 = Broda and Schmidt (1978), 13 = Abenov and Svanbaev (1982), 14 = Torbett et al. (1982), 15 = Veluvolu and Levine (1984), 16 = Seville and Williams (1989), 17 = Shults et al. (1990), 18 = Stanton et al. (1992), 19 = Seville et al. (1992), 20 = Seville and Stanton (1993), 21 = Thomas and Stanton (this study), 22 = Thomas (unpubl. data), 23 = Wilber (pers. comm.).

† Seville and Stanton (1993) suggested synonymizing *E. larimerensis* and *E. lateralis,* so data for these 2 species are combined.

‡ Unidentified species, this study.

found infecting Gunnison's prairie dogs. Additionally, *E. beecheyi, E. callospermophili,* and *E. morainensis* exhibited high prevalences in both hosts. The unidentified eimerian species occurred at much higher prevalences in rock squirrels than in prairie dogs, but this may be due to small sample size. However, it is possible that the rock squirrel is a primary host and that the prairie dog is a host of secondary importance.

Stanton et al. (1992) described a stable eimerian guild in Wyoming ground squirrels (*Spermophilus elegans elegans* Kennicott, 1863), with 6 species present at consistent prevalences across populations and over time. The observed eimerian assemblage in Gunnison's prairie dogs more closely resembles that described for Wyoming ground squirrels (Shults et al., 1990; Stanton et al., 1992) than of any other sciurid host for which prevalence data are available (Vetterling, 1964; Seville and Williams, 1989; Seville et al., 1992). All 6 species found in Wyoming ground squirrels also infect Gunnison's prairie dogs. Additionally, the 3 most prevalent species in both Wyoming ground squirrels and Gunnison's prairie dogs were *E. beecheyi, E. callospermophili,* and *E. morainensis,* whereas *E. larimerensis, E. bilamellata,* and *E. spermophili* always occurred in prevalences below 20% in both host species.

Characteristics of host populations (e.g., geographic distribution, population density, body size, population growth rate) play an important role in shaping parasite communities (Price, 1990). Positive correlations have been reported between host geographic range and the species richness of the associated parasite community (e.g., Price, 1980; Price and Clancy, 1983; Price et al., 1988; Aho, 1990), and the probability of exchange of parasites within and among host species increases with increased host geographic range (Price, 1990). There is a strong correlation

($R^2 = 0.971$) between the size of the geographic range of eimerian species of ground-dwelling sciurids and the number of host species/eimerian species (Fig. 1). As parasites are exchanged between related sympatric host species, parasite host specificity declines. Additionally, the high densities and population growth rates characteristic of most sciurids allow maintenance of a diverse parasite community on a local level by increasing the incidence of transmission between hosts and maintaining a large population of new hosts available (e.g., with low immunological resistance) for parasite colonization (Price, 1990).

Duszynski (1986) challenged the paradigm of high host specificity among eimerian species (Marquardt, 1973; Joyner, 1982) and proposed that mammalian coccidia are less rigid in their host requirements, especially when hosts occur in high densities and the probability of transmission is high. The 8 eimerian species in this study inhabit a wide geographic range and have been recovered from 19 host species representing 3 genera (Table 1). The individual eimerian species have been reported infecting as many as 16 of these host species in 3 distinct genera. We propose that this ability to infect a wide range of abundant and ubiquitous host species across large geographic regions enhances the stability and persistence exhibited by this eimerian assemblage.

Acknowledgments

This research was supported by NSF grant #BSR-89-9887 and the University of Wyoming Office of Research. Special thanks are extended to Newton Kingston, who provided valuable comments on the manuscript.

Literature Cited

Abenov, D. B., and S. K. Svanbaev. 1982. Materialy po izucheniyu koksidii reliktovogo suslika (*Citellus reliktus*) v Kazakhstane. Pages 3–5 *in* P. Zayanchkauskas and S. Bizyulyavichyus, eds. Kishechnye Prosteishie. Institut Zoologii Parasitologii, Litovsk SSR Akademiya Nauk SSSR, Vil'nyus.

Aho, J. M. 1990. Helminth communities of amphibians and reptiles: comparative approaches to understanding patterns and processes. Pages 157–195 *in* G. Esch, A. Bush, and J. Aho, eds. Parasite Communities: Patterns and Processes. Chapman and Hall, New York.

Andrews, J. M. 1928. New species of coccidia from the skunk and prairie dog. Journal of Parasitology 14:193–194.

Broda, R. J., and G. D. Schmidt. 1978. Endoparasites of the spotted ground squirrel, *Spermophilus spilosoma* Bennett, 1833, from Colorado. Journal of Helminthology 52:323–326.

Duszynski, D. W. 1986. Host specificity in the coccidia of small mammals: fact or fiction? Symposia Biologica Hungarica 33:325–337.

Hall, P. R., and F. Knipling. 1935. *Eimeria franklinii* and *Eimeria eubeckeri,* two new species of coccidia from the Franklin ground squirrel, *Citellus franklinii* Sabine. Journal of Parasitology 21:128–129.

Henry, D. P. 1932. Observations on the coccidia of small mammals in California, with descriptions of seven new species. University of California (Berkeley), Publications in Zoology 37:279–290.

Hilton, D. F. J., and J. L. Mahrt. 1971. *Eimeria spermophili* n. sp. and other *Eimeria* spp. (Protozoa, Eimeriidae) from three species of Alberta *Spermophilus* (Rodentia, Sciuridae). Canadian Journal of Zoology 49:699–701.

Joyner, L. P. 1982. Host site and specificity. Pages 35–62 *in* P. L. Long, ed. The Biology of the Coccidia. University Park Press, Baltimore, Maryland.

Levine, N. D., and V. Ivens. 1965. The Coccidian Parasites (Protozoa, Apicomplexa) of Rodents. Illinois Biological Monograph Number 51. University of Illinois Press, Urbana. 248 pp.

———, ———, and F. J. Kruidenier. 1957. New species of *Eimeria* from Arizona rodents. Journal of Protozoology 4:80–88.

Marquardt, W. C. 1973. Host site and specificity. Pages 23–43 *in* D. M. Hammond and P. L. Long, eds. The Coccidia. University Park Press, Baltimore, Maryland.

Pellérdy, L., and A. Babos. 1953. Zur Kenntnis der kokzidien aus *Citellus citellus.* Acta Veterinaria Academiae Scientiarum Hungaricae 24:127–131.

Price, P. W. 1980. Evolutionary Biology of Parasites. Princeton University Press, Princeton, New Jersey. 237 pp.

———. 1990. Host populations as resources defining parasite community organization. Pages 21–40 *in* G. Esch, A. Bush, and J. Aho, eds. Parasite Communities: Patterns and Processes. Chapman and Hall, New York.

———, and K. M. Clancy. 1983. Patterns in number of helminth parasite species in freshwater fishes. Journal of Parasitology 69:449–454.

———, M. Westoby, and B. Rice. 1988. Parasite-mediated competition: some predictions and tests. American Naturalist 131:544–555.

Ryšavý, B. 1957. Poznamky k fauné kokcidii volné zijicich drobnych ssavcú v Ceskoslovensku. Ceskoslovenska Parasitologie 4:331–336.

Seville, R. S., and N. L. Stanton. 1993. Eimerian guilds (Apicomplexa: Eimeriidae) in Richardson's ground squirrels (*Spermophilus richardsonii*). Journal of Parasitology 79:973–975.

———, and ———. 1993. Synonymy of *Eimeria larimerensis* with *Eimeria lateralis.* Journal of Parasitology 79:970–972.

———, D. M. Thomas, R. Pickering, and N. L. Stanton. 1992. Species of *Eimeria* from the thirteen-lined ground squirrel, *Spermophilus tridecemlineatus,* from Wyoming. Great Basin Naturalist 52: 309–312.

———, **and E. S. Williams.** 1989. Endoparasites of the white-tailed prairie dog, *Cynomys leucurus,* at Meeteetse, Park County, Wyoming. Proceedings of the Helminthological Society of Washington 56: 204–206.

Shults, L. M., R. S. Seville, N. L. Stanton, and G. E. Menkens, Jr. 1990. *Eimeria* sp. (Apicomplexa: Eimeriidae) from Wyoming ground squirrels (*Spermophilus elegans*) and white-tailed prairie dogs (*Cynomys leucurus*) in Wyoming. Great Basin Naturalist 50:327–331.

Stanton, N. L., L. M. Shults, M. Parker, and R. S. Seville. 1992. Coccidian assemblages in the Wyoming ground squirrel, *Spermophilus elegans elegans.* Journal of Parasitology 78:323–328.

Todd, K. S., and D. M. Hammond. 1968a. Life cycle and host specificity of *Eimeria callospermophili* Henry, 1932 from the Uinta ground squirrel, *Spermophilus armatus.* Journal of Protozoology 15: 1–8.

———, **and** ———. 1968b. Life cycle and host specificity of *Eimeria larimerensis* Vetterling, 1964, from the Uinta ground squirrel, *Spermophilus armatus.* Journal of Protozoology 15:268–275.

———, ———, **and L. C. Anderson.** 1968. Observations on the life cycle of *Eimeria bilamellata* Henry, 1932 in the Uinta ground squirrel *Spermophilus armatus.* Journal of Protozoology 15: 732–740.

Torbett, B. E., W. C. Marquardt, and A. C. Carey. 1982. A new species of *Eimeria* from the golden-mantled ground squirrel, *Spermophilus lateralis,* in northern Colorado. Journal of Protozoology 59: 157–159.

Veluvolu, P., and N. D. Levine. 1984. *Eimeria beldingi* n. sp. and other coccidia (Apicomplexa) of the ground squirrel *Spermophilus beldingi.* Journal of Protozoology 31:357–358.

Vetterling, J. M. 1964. Coccidia (*Eimeria*) from the prairie dog, *Cynomys ludovicianus ludovicianus,* in northern Colorado. Journal of Protozoology 11: 89–91.